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ABSTRACT

Analogous auditory and visual central-incidental learning tasks were administered to 24 students from each of the second, fourth, and sixth grades. The visual tasks served as another modification of Hagen's central-incidental learning paradigm, with the interpretation that focal attention processes continue to develop until the age of 12 or 13 years. The auditory tasks were administered to the same students in order to extend this interpretation to auditory selective attention processes and to assess the feasibility of a modality independent central process for allocating and maintaining attention. As predicted, central task learning increased with age for both auditory and visual presentations. Visual incidental learning followed the predicted curvilinear age trend for boys but not for girls. Auditory incidental learning increased with age for boys but not for girls. These results suggest that auditory selective attention processes develop more slowly than visual selective attention processes, especially for boys. (Author)

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The Development of Visual and Auditory Selective Attention Using the Central-Incidental Paradigm

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Recent research concerned with the development of selective attention has centered around interpretation of age trends in a central-incidental learning paradigm with visual materials (Maccoby and Hagen, 1965; Hagen, 1967; Druker and Hagan, 1969; Wheeler and Dusek, 1973). The central learning task in such studies requires children to remember only one type of picture (i.e., animals) from pairs of pictures which are presented on one stimulus card. In the incidental learning task the children are asked to match the picture pairs as they had appeared during the central task. The expected result is that a trade-off should occur, such that the more attention that is directed to the central task, the less attention will be available for the incidental task (Hagen, 1972).

The original studies employing this general paradigm (Maccoby and Hagen, 1965; Hagen, 1967) used Broadbent's filter theory (1958) as the model for age trend predictions. As predicted, central learning improved with age while incidental learning did not improve across the ages seven to thirteen. An unexpected finding in these studies resulted from a distraction condition which hindered central learning to roughly the same degree at all ages but hindered incidental learning only at the oldest age level (13 years). In other words, under information overload conditions, the older children "gave up" incidental information in order to attend more effectively to the central information. Additional evidence for this interpretation is supplied by the negative correlations between central and incidental learning scores for the oldest group (Hagen, 1967).

The filter theories of selective attention (i.e., Broadbent, 1958; Triesman, 1969) would predict such a result, but such models cannot explain

why this decline should occur only at the oldest age level. This general trend of a curvilinear relationship between age and incidental learning has held up under a variety of manipulations with the experimental design (Wheeler and Dusek, 1973; Hale and Piper, 1973) and stimulus properties (Druker and Hagen, 1969; Sabo and Hagen, 1973). Thus, in recent reviews of the research on the development of selective attention, Hagen (1972; Hagen and Hale, 1973) has turned from a filter theory interpretation of these trends to an explanation based on Neisser's (1967) two-stage model of selective attention.

Neisser (1967) has postulated two stages of selective attention in the visual modality; preattentive processes and focal attention processes. Preattentive processes isolate objects or portions of the stimulus array into units in a "global and wholistic" manner. Focal attention involves the host of operations with which we actively analyze and make internal constructions of the stimulus unit which has been isolated for further processing. Neisser (1967) emphasizes internal synthesis as the primary process for directing attention. Hagen (1972) has interpreted the central-incidental learning trends in terms of this model by equating the pre-attentive stage with the act of isolating the relevant member of the picture pairs. He presents evidence from several sources which strongly implies that the children in such studies (i.e., ages 7 to 13) have adequately developed the preattentive processes necessary for distinguishing the picture pairs (Hagen, 1967; Hagen, Meacham, and Mesibov, 1970; Hagen, 1972; Hagen and Hale, 1973). Thus, the Ss are utilizing second stage (focal attention) processes for focussing and maintaining attention on the relevant pictures. The finding that central learning improves with age supports the notion that these second stage processes develop with age.

The unexpected finding that incidental learning actually declines at the oldest age level (13 years) has led Hagen to postulate that second stage processes are not fully developed until the 11 to 13 year range (Hagen, 1972). The children who employ second stage (focal attention) processes effectively are able to completely ignore the irrelevant member of the animal-object pairs so that their incidental learning scores drop to a chance level of performance.

The research on selective attention using the incidental-intentional learning paradigm concerned only the visual modality. A general model of attentional processes implies a central process for the allocation of attention rather than separate modality-specific processes. Neisser (1967) has developed an analogous model for auditory attention consisting of (passive) preattentive processes and active analysis-by-synthesis processes. The preattentive processes act as a preliminary filter for "identification of words or other cognitive units" (Neisser, 1967, p. 213). Similar to the visual preattentive processes, the main function of the first stage is to isolate units (i.e., words) for further processing. During the second stage processes the listener synthesizes "inner speech (at some level of abstraction) to match the input" (Neisser, 1967, p. 213). Thus in the auditory modality, the processes of selective attention act on the isolated units of the stimulus array by means of internal constructions. Although the preattentive processes seem to operate in a modality specific manner, the second stage processes seem to be controlled by a more central process. Therefore, the same developmental trends should occur on an auditory central-incidental learning task as those generally found on visual central-incidental tasks.

The purpose of the present study was to replicate the general developmental trends in selective attention using a modification of the visual central-incidental learning tasks, and to extend the study of selective attention by using an analogous auditory central-incidental learning task. A comparison of performance for children of different ages on central-incidental tasks differing only in modality of presentation could reveal similarities and/or differences in the development of auditory and visual selective attention. If second stage processes are controlled by a central process, rather than by modality-specific processes, then central and incidental task performance should be similar on the auditory and visual tasks.

Method

Subjects

Seventy-two children were selected from grades two, four, and six of a semi-rural elementary school in central Pennsylvania. The twenty-four subjects from each grade level were randomly assigned to one of two subgroups with an equal number of boys and girls in each group. All subjects were of average intelligence and were primarily from lower middle-class socioeconomic backgrounds. The mean chronological ages were 8.2, 10.0, and 12.0 years for the second, fourth, and sixth grade samples, respectively.

Materials

The twenty-five most frequent mono- or di-syllabic animal names and household objects were selected from the Word Frequency Book (Carroll, Davies, and Richman, 1972). With reference to a table of random numbers, ten animals and ten objects were assigned to the visual task and ten of each to the auditory task. The animals and objects were paired on a random basis,

and these pairings remained constant throughout all trials. The ten stimulus pairs for the visual central task were drawn on 5 x 8 inch white cards with the top-bottom positions for animals and objects counterbalanced. Each picture was approximately three inches square and were separated by one inch. The recall probe cards had the picture of the animal (or household object) to-be-recalled centered on a 5 x 8 inch white card.

The ten stimulus pairs for the auditory central task were recorded and presented to the subjects through headsets on a Sony (TC-800) portable tape recorder. Each pair was presented serially within approximately one second with a one second pause between pairs. For five randomly selected pairs the animal name was always first, and for the other five pairs the household object name was always first. The recall probes for the auditory task were also recorded on the stimulus tape.

Procedure

Subjects were tested individually in one session lasting approximately twenty-five minutes. The order of task presentation - visual task first or auditory task first - were counterbalanced so that twelve subjects from each grade received one of the two possible orders. The subject was told that he was going to play two "memory games" - a "picture game" and a "listening game." The experimenter gave the appropriate central task instructions (with no indication of the incidental task) using three practice trials composed of animal-object pairs not used in the actual experimental tasks. The to-be-recalled stimulus (animal or household object) was determined randomly for each subject and remained constant across the two tasks. After the experimenter was certain that the subject understood the instructions from the performance on the practice trials, the subject was administered

the ten experimental trials for the central task. The corresponding incidental task followed immediately after the last trial. The subject was given a short break, and the second central task was begun. After all tasks had been completed, each subject was asked a series of questions concerning his general strategy for approaching the tasks similar to the questionnaire of Druker and Hagen (1969).

The stimulus cards for the visual central task were presented successively to the subjects with five pairs in each trial. The cards were held at the subject's eye level for two seconds each and placed on the table in a left-to-right order. Each card was numbered 1, 2, 3, 4, or 5 on the reverse side corresponding to its serial position in that particular trial. Immediately following the presentation of the fifth card, the first (immediate) probe card was held at the subject's eye level. The subject was instructed to point to the card which had that picture on the front; as soon as he/she responded the second (delayed) probe card was held up. Each serial position was probed four times in the ten trials, twice as an immediate probe and twice as a second probe. Each animal (or household object) was probed twice, once as an immediate probe and once as a delayed probe. Thus for the visual central task there were ten trials with ten immediate and ten delayed serial position recall probes. The subjects were then shown ten manila folders one at a time for the visual incidental task. On one section of each folder an animal was drawn on the appropriate half of a 5 x 8 inch white card, on the other section four household objects were drawn on 5 x 8 inch white cards. As each folder was shown, the experimenter asked, "What went with (bear)? Was it this one?, etc.," while indicating each of the four choices in turn. The score for the visual

incidental learning was the number of correctly matched pairs for the ten trials.

For the auditory central task, five cards were placed in front of the subject numbered from left to right. The subject was told that he would hear five pairs of words and to follow the numbered cards with his hand as he heard the first, second, third, fourth, and fifth animal (or household object) name, respectively. This procedure was employed only for the first practice trial to insure that the subject could keep track of the order of presentation. The five word pairs in each auditory central task trial were presented at a rate of two seconds per pair. The first (immediate) probe followed one second after the last pair and the second (delayed) probe followed five seconds later. The subject was instructed to point to the card which corresponded to "the order that you heard the animal (or household object) names - first, second, third, fourth, or fifth." "The format of the auditory central task was identical to the visual central task, although the actual animals and objects were different. Thus, for the auditory central task there were ten trials with ten immediate and ten delayed serial position recall probes. The auditory incidental task followed immediately after the last trial; the subjects were asked, "What did you hear with (monkey)? Was it (monkey-pillow), (monkey-book), etc.?" until four choices were given. The score for the auditory incidental task was the number of correctly matched word pairs for the ten trials.

Thus, four tasks were administered to each subject in the experimental session: an auditory central task, an auditory incidental task, a visual central task, and a visual incidental task. No specific feedback was given on any of the tasks as to the correctness of a response. General social reinforcement (i.e., "You're doing fine") was given to all subjects

in order to maintain an appropriate level of attention and motivation on the tasks.

Results

The recall scores for the central learning tasks and for the incidental learning tasks were analyzed separately as mixed Latin square designs (Meyers, 1972, p. 286-91) since the scores for each task were based on different measures. The incidental task scores were subjected to a 3 x 2 x 2 x 2 analysis of variance with the factors of grade level, order of presentation, sex, and task modality (as a repeated measure). The central task scores were subjected to a similar analysis with the additional repeated measure of recall probe - immediate or delayed recall. The mean central and incidental recall scores for the two task modalities are presented in Table 1.

Insert Table 1 about here.

Central Learning Task

The significant effects in the central learning analysis were grade level, $F(2, 60) = 32.91$, $p < .001$ and recall probe, $F(1, 60) = 16.77$, $p < .001$. All paired comparison follow-up tests reported in this study employed the Newman-Keuls procedure (Meyers, 1972, p. 366) at the $p = .05$ level of significance. The central learning scores increased significantly from second ($\bar{X} = 3.80$) to fourth ($\bar{X} = 4.80$), and from fourth to sixth grade ($\bar{X} = 6.27$). Neither the grade level x task modality interaction, $F(2, 60) = 2.94$, nor the task modality main effect, $F(1, 60) = 2.78$, was significant although the general trend showed visual central task scores

higher than auditory central task scores. The significant recall probe main effect revealed that the immediate probe condition led to more correct serial positions recalled ($\bar{X}$ = 5.31) than the delayed probe condition ($\bar{X}$ = 4.61).

Incidental Learning Task

The significant effects in the incidental learning analysis were order of task presentation, $F(1, 60) = 8.84$, $p < .01$, and the grade level x sex x task modality interaction, $F(2, 60) = 7.62$, $p < .01$. The order effect showed that subjects performed better on the second incidental task ($\bar{X}$ = 5.12) than on the first incidental task ($\bar{X}$ = 4.21) regardless of whether the auditory task or the visual task was presented first. The hypothesis of a decrease in incidental learning at the oldest age level does not seem to be supported in light of the non-significant grade level effect, $F(2, 60) = 0.31$. However, the means for the grade level x sex x task modality interaction shown in Figure 1 reveal some interesting trends.

Insert Figure 1 about here.

The sixth grade boys ($\bar{X}$ = 3.92) followed the predicted trend for the visual incidental task by recalling significantly less animal-household object pairs than the fourth grade boys ($\bar{X}$ = 5.92), whereas the sixth grade girls ($\bar{X}$ = 5.00) recalled (non-significantly) more animal-object pairs than the fourth grade girls ($\bar{X}$ = 4.25) on the visual incidental task. For the auditory incidental task the sixth grade girls followed the predicted trend, although the difference between sixth grade girls ($\bar{X}$ = 3.50) and fourth grade girls ($\bar{X}$ = 4.67) was not significant. The sixth grade

boys ($\bar{X}$ = 6.33) recalled significantly more animal-household object pairs than the fourth grade boys ($\bar{X}$ = 4.50) on the auditory incidental task. No differences between the fourth grade groups and the corresponding second grade groups reached the .05 level of significance. The difference between sixth grade boys ($\bar{X}$ = 6.33) and second grade boys ($\bar{X}$ = 4.25) was significant for the auditory incidental task.

Questionnaire

The responses to the questionnaire administered at the completion of the tasks were categorized into two general strategies: (1) labelled both animals and household objects or (2) labelled (or rehearsed) the relevant items only. As expected, the older children employed the more task-appropriate strategy more often than the young children for central learning as 19 of 24 sixth grade subjects, 14 of 24 fourth grade subjects, and 8 of 24 second grade subjects responded that they "named the animals (or household objects) only." The responses were too vague to distinguish separate approaches to auditory and visual tasks, so only one strategy was recorded for each subject. An additional question concerning whether the subjects changed strategies after the completion of the first task revealed that four second grade, four fourth grade, and eight sixth grade subjects expected the incidental learning questions on the second of the two tasks. These results and the significant order of task presentation effect are evidence of the problems encountered in presenting each subject with two similar tasks. The overall result of this order effect is to spuriously inflate incidental learning scores. Since the grade x order interaction, $F(2, 60) = 1.04$, was not significant for the incidental tasks, the age trend interpretations should not be seriously affected.

Discussion

Central task learning increased linearly with age for subjects 8, 10, and 12 years old for both auditory and visual presentations. Incidental task learning followed the predicted curvilinear trend for boys on the visual incidental task. One would predict from Neisser's (1967) two-stage auditory attention model that there would be a decrease in incidental learning as second stage attention processes develop. Incidental task learning remained stable across the three age levels for girls, but interestingly these non-significant age trends showed opposite developmental patterns from those of the boys as shown in Figure 1.

In general, the results of the present visual tasks support Hagen's (1972) interpretation that second-stage focal attention processes reach full development in the 11 to 13 age range. In spite of the changes in procedure from simultaneous presentation to successive presentation of central task picture pairs with two recall probes per trial and from a matching to a multiple-choice recognition task for assessing incidental learning, the results of the present visual tasks are consistent with other manipulations of the central-incidental learning paradigm (Hagen, 1967; Druker and Hagen, 1969; Wheeler and Dusek, 1973). An exception to this interpretation occurred in a study by Hale and Piper (1973) who investigated several types of central task stimulus pairs in different arrangements. Their investigation demonstrated that if the stimuli are readily analyzeable into separate units (as in separated picture pairs) selective attention will be employed, but if the stimuli contain redundant information (as in colored shapes) it is more efficient to encode both attributes of the stimuli. Thus, not only do older children employ second stage

focal attention processes more effectively than young children for focussing and maintaining attention to the task-relevant stimuli, they are better able to decide when it is more efficient to encode selectively (Hagen and Hale, 1973). The results of the strategy questionnaire in the present study lends some support to this argument as the older children more frequently reported labelling or rehearsing the relevant member of the picture pairs only, whereas the younger children more frequently reported labelling both relevant and irrelevant pictures during the central task.

The sex differences in the patterns of visual incidental task performance with age could be interpreted to suggest a different pattern of development for boys and girls. However, previous research with similar tasks has shown that third and fifth grade boys remembered more incidental pairs than girls (Wheeler and Dusek, 1973). Druker and Hagen (1969) found that fourth, sixth, and eighth grade boys remembered more central task serial positions than girls. These inconsistent trends are not readily interpretable and leave the question of sex differences in the development of visual selective attention unresolved at this time.

Both the visual and auditory tasks were administered to each subject in order to study the similarity of visual and auditory processes for focussing and maintaining attention to relevant portions of a stimulus array. Evidence for modality-specific processing was not found in the central task analyses since neither the task modality main effect nor any of the task modality interactions reached significance. On the other hand, the incidental task analyses revealed developmental differences between visual and auditory processes. This difference is reflected in Figure 1 where differential patterns of change from fourth to sixth grade are found for boys and girls on the auditory and visual incidental tasks.

The auditory incidental learning task resulted in a weak curvilinear age trend for girls (as predicted from the two stage model) but in a linear increasing age trend for boys. Since the sixth grade boys recalled more irrelevant pairs than the sixth grade girls, this last result could be interpreted that boys develop auditory selective attention processes more slowly than girls. Although the corresponding grade level x sex x task modality interaction was not significant for the central learning tasks, inspection of the cell means showed that the sixth grade girls recalled more serial positions ($\bar{X}$ = 6.42) than the sixth grade boys ($\bar{X}$ = 5.33) on the auditory central task. Siegel and Allik (1973) found a similar sex effect where kindergarten, third, and fifth grade girls performed better than corresponding groups of boys on a task similar to the auditory central task. These data suggest that girls may have an advantage in focussing attention on the relevant word only up to twelve or thirteen years of age when the boys seem to catch up. However, Doyle (1973) found no sex differences with subjects of 8, 11, and 14 years of age on tasks requiring them to select and later recall one word of a simultaneously presented pair.

In summary, Neisser's (1967) two stage model of selective attention has been extended to interpret results of auditory central-incidental learning tasks as well as visual central-incidental learning tasks. The non-significant but consistent differences between auditory and visual central learning and the differential patterns of development for auditory and visual incidental learning suggest that auditory selective attention abilities develop more slowly than visual selective attention abilities, especially for boys. Further investigations should include an older age

group (14-15 years) to test the prediction that auditory selective attention develops at a later age than visual selective attention.

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Footnote

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Table 1

Mean Central and Incidental Task Recall Scores

For Each Condition for Auditory and Visual Presentations

	Auditory Tasks		Visual Tasks	
Conditions	Central	Incidental	Central	Incidental
Grade:				
Two	3.96	4.25	3.65	4.71
Four	4.56	4.58	5.04	5.08
Six	5.86	4.92	6.67	4.46
Order:				
First Task	4.90	4.22	4.78	4.19
Second Task	4.69	4.94	5.46	5.31
Sex:				
Boys	4.57	5.03	5.03	4.86
Girls	5.03	4.14	5.21	4.64
Probes:				
Immediate	5.26	——	5.35	——
Delayed	4.33	——	4.89	——

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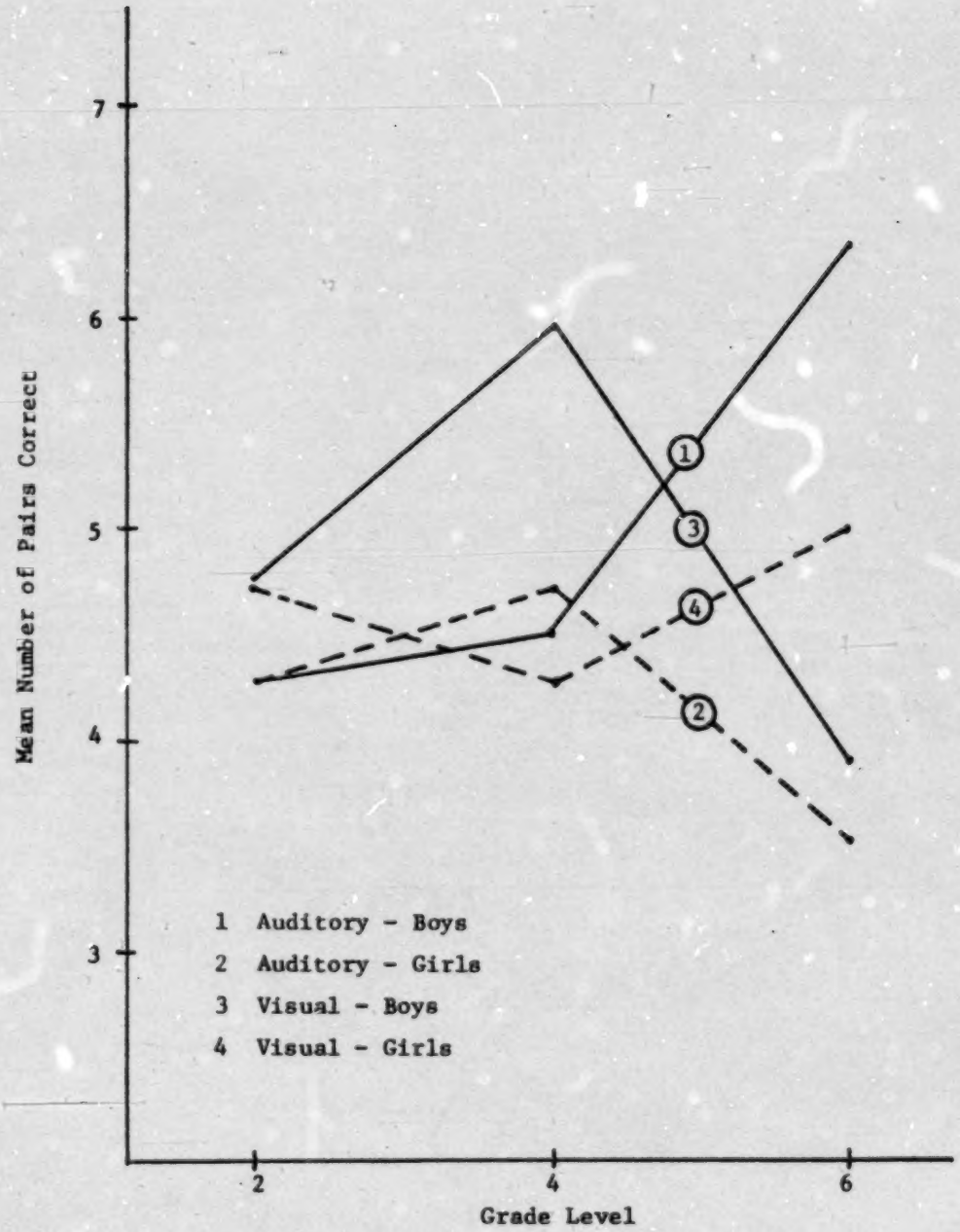

Figure 1. Mean number of animal-household object pairs recalled (incidental task) as a function of grade, sex, and task modality.